DESCRIPTION OF AN ABNORMAL LOBSTER CHELIPED.[1]

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While visiting the United States Fish Hatchery at Gloucester, Mass., during the summer of 1908, my attention was called to an abnormal lobster (*Homarus americanus*) which was at that time preserved in formalin. The specimen was taken in Gloucester harbor by a local fisherman in the preceding May, and was kept alive in an aquarium at the hatchery about a week before it died. Through the kindness of Mr. Corliss, superintendent of the hatchery, I was enabled to secure the specimen for description. The abnormality consists of a double extra claw on the left cheliped, and while not different in general type from specimens which have previously been described, it does possess certain peculiarities which would appear to justify placing it on record. The right cheliped was missing when the lobster was caught. From the appearance of the scar, and the fact that there is no evidence of regeneration having begun, it is probable that the loss of the appendage was comparatively recent. The especial interest of the present specimen lies in the fact that the extra claws are so well developed and that their arrangement is almost schematic of the principles, or "rules" of secondary symmetry laid down by Bateson (**1894**, p. 479), if we make allowance for the torsion which normally occurs in the cheliped of the lobster.

DESCRIPTION.

The lobster possessing this abnormality is a male, 237 mm. in length from tip of rostrum to end of telson.

Claws.—The part which represents the primary claw (*PrL* of figures) is practically a normal left chela of the *crushing* type, except for an abnormal outgrowth from its outer (morpho-

[1] Paper from the Zoölogical Laboratory, Sheffield Scientific School of Yale University.

logically posterior) face. This outgrowth does not arise from the middle of the outside face of the primary propodus, but rather from the ventral half of its surface, the significance of which in its relation to the planes assumed by the various claws will be discussed further on. In general appearance the outgrowth represents a more or less completely doubled extra claw,[1] and according to the classification given by Emmel (1907) would fall in the class having "abnormal processes arising from the normal propodite," and under this heading it would probably have to be classed with those having "two extra indices and double extra dactyl." It differs, however, from any previously described specimens in this category, so far as I am aware, in the degree to which the double dactyl approaches the condition of two separate dactyls, it being markedly bifurcated at the tip, whereas in the case (specimen No. 4) described by Emmel, what he takes to be the double dactyl is only a small undivided "stump." The strength of his interpretation lies in the fact that both the double dactyl and the index in other specimens may be represented by an undivided process, the double character of which is indicated by its having teeth on two opposite sides (cf. Emmel's specimens No. 2 and No. 3).

Considering now only the supernumerary outgrowth, the basal part, which represents a double propodus, has along its ventral side a deep groove, as may be seen in Fig. 2. The continuation of the divergent ridges which bound this groove form two separate and distinct indices ($I'R$ and $I'L$), each of which, taken by itself, appears like a practically normal index. They are, moreover, essentially alike except that their relations of symmetry are reversed, so that one would appear as the image of the other in a plane mirror placed between them. This relation will, however, be discussed more fully later. The opposing dactyl is also divided for nearly half its length, on account of the bifurcation mentioned above, the divergent branches ($D'R$ and $D'L$) meeting in opposition the corresponding extra indices ($I'R$ and $I'L$). The double character of the dactyl clear to its base is indicated by the fact that the rows of teeth on the two tips continue in separate and distinct lines down the inside of the basal portion. Further-

[1] The extra claws are somewhat smaller than the normal or primary claw.

more, on the dorsal side near the base, the single spine of the primary dactyl (*SpDL*) is represented by two similar spines (*SpD'R* and *SpD'L*). The row of spines down the dorsal ridge of the extra propodite is very weak, whereas there is a row of strong spines in the corresponding position on the normal propodite (*PrL*). This is a result of the "compounding" at this level, to be mentioned again below (p. 264).

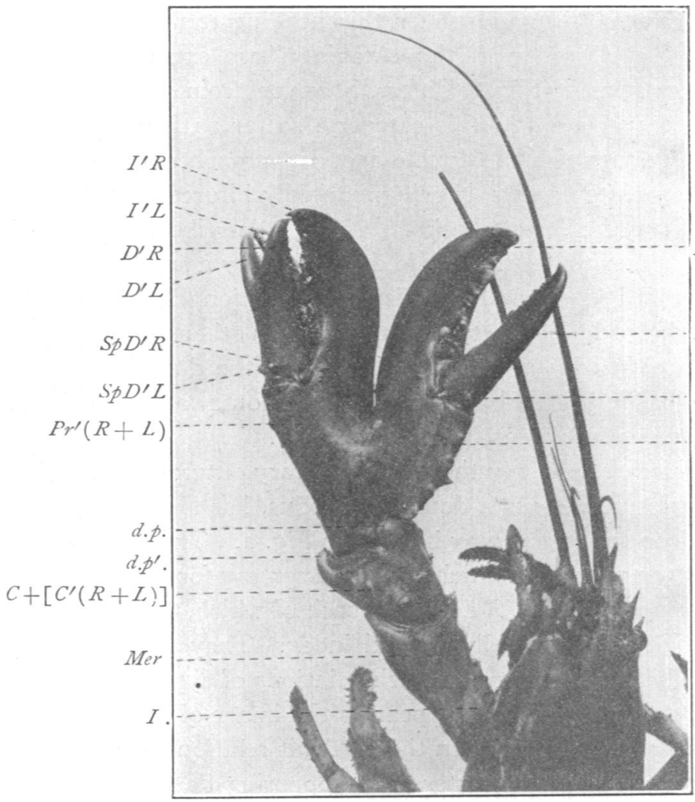

FIG. 1. Photograph of abnormal cheliped from dorsal side. (For explanation of abbreviations used in the figures see list on p. 267.)

The distance between the tips of the two diverging extra dactyls (*D'R* and *D'L*) is very slightly greater than that between the tips of the two extra indices (*I'R* and *I'L*), so that if the double dactyl closed down squarely it would tend to make the tips lap

over on the outside (morphologically dorsal side) of each of the index tips; but, as may be seen in Fig. 1, they do not close squarely, but instead the double claw shuts in such a manner that *both the dactyl tips overlap the index tips on the side toward the normal (primary) claw.* Thus $D'L$ overlaps on the *ventral* side of $I'L$, and $D'R$ on the *dorsal* side of $I'R$. In this connection it

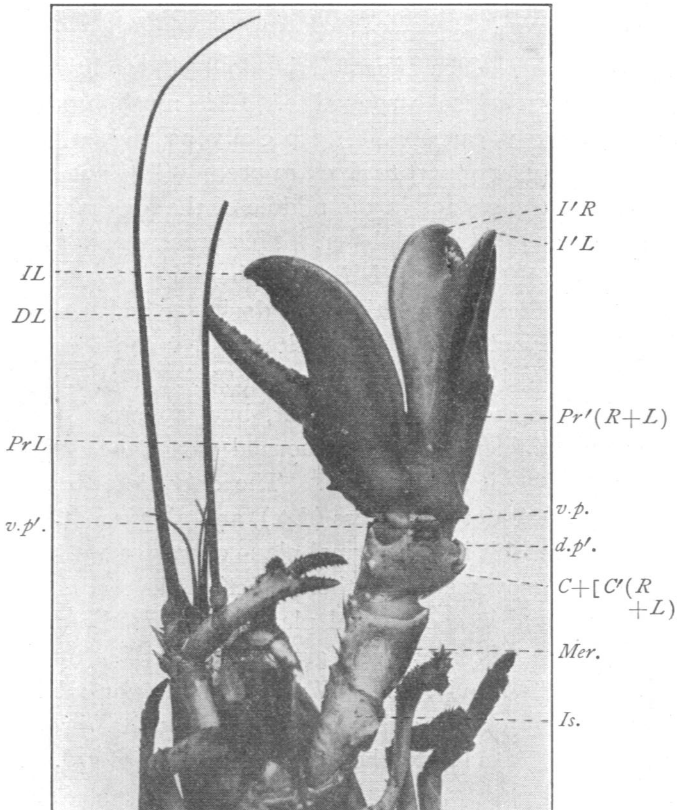

FIG. 2. Photograph of abnormal cheliped from ventral side.

is interesting to note that the normal dactyl (DL) when closed overlaps decidedly on the ventral side of its index (IL), that is, on the side away from the extra claws. All these dactyls thus overlap their respective indices on the side toward the median plane of the animal, in this matter not agreeing with the morpho-

logical symmetry which obtains in other respects. As is to be expected the teeth on the extra claws are plainly, like those of the normal claw, of the "crusher" type.

No attempt was made to study the internal anatomy further than to note that the extra double dactyl has *two* adductor tendons, but only a single abductor tendon. This condition is what might be expected from the way in which the two extra dactyls ($D'R$ and $D'L$) are "compounded" (*vide infra*) at their base.

Carpopodite.—The effect of the doubled condition distally is very evident in the carpopodite. It is much broader distally than a normal carpopodite, especially as viewed from above. This is due in large part to an extra process (*d.p'.*) on the posterior face of the appendage in the middle of the area which is evenly concave in the normal lobster. This process is in line with the double dactyl ($D'L$ and $D'R$), thus having the same relations to this doubled extra part that the dorsal articular process (*d.p.*) has to a normal dactyl. Opposite *d.p'.*, in the concavity of the anterior side, is a smaller process (*v.p'.*). The normal ventral articular process (*v.p.*) is present, but, apparently due to the disturbing influence of the abnormal parts, the articulation of the chela with it is not close.[1] The only close articulation is, then, with the dorsal process (*d.p.*), and although the chela can be moved on this in the normal plane of movement, it is capable of a slight movement in other directions as well. The hinge-like movement in the normal plane (*i. e.*, on the axis between *d.p.* and *v.p.*) is, moreover, greatly limited by the secondary processes (*d.p'.* and *v.p'.*). Whereas in the normal lobster the claw (propodite) can swing on the carpopodite through an arc of about 90°, it is limited here to a movement of 25°. A smooth spot on the shell (*x*, Fig. 3) shows where *d.p'.* has stopped the movement of the claw in that direction, and the nature of the surfaces at *v.p.* shows that in the living animal there must have been some movement of the claw in the plane at right angles to the normal plane of movement.

[1] It would look as though the presence of muscles belonging to the abnormal part, which by their action tended to swing the claw on the secondary axis *d.p'.–v.p'.*, had prevented a close articulation at *v.p.* A careful study of the musculature of the carpopodite would be of much interest, but it was found impracticable to make such a study at the present time.

The arrangement of certain of the spines also goes to show that *d.p'.* is to be considered as the equivalent of a double dorsal articular process corresponding to the doubled abnormal claw; but there is no need to go into the details of this matter, which can be made out in the figures.

Meropodite.—Here, too, the abnormality is evident. The joint is relatively much thicker than the corresponding joint in a

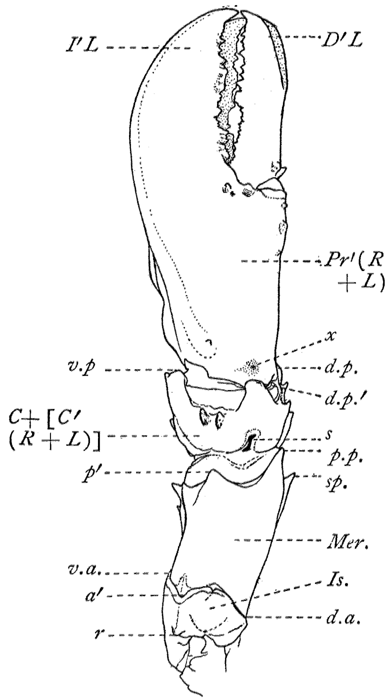

FIG. 3. Abnormal cheliped seen from posterior side (really a little ventro-posterior).

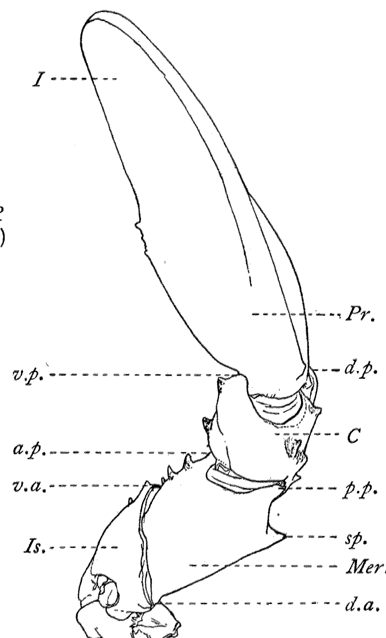

FIG. 4. Normal left cheliped of a lobster, seen from posterior side (really a little ventro-posterior).

normal lobster. The normal plane of articulation between the meropodite and the carpopodite is morphologically horizontal, the articular processes therefore being anterior (Figs. 3 and 4, *a.p.*) and posterior (*p.p.*). These processes and the articulation are essentially normal in the abnormal claw, but in the concavity of the (morphologically) ventral side is a large process (*p'*) which apparently represents one point for an incipient axis of articu-

lation in a plane at right angles, or nearly so, to the normal articulation. This condition corresponds to that between the carpopodite and the propodite, described above. There is no evidence of the corresponding process on the opposite side, however, nor is there any articulation with *p′*, the distal portion swinging normally on the axis between *a.p.* and *p.p.* But while this movement covers an arc of approximately 45° in a normal claw, it is here limited to a range of between 25° and 30°. There is no sign of duplication of the large spine (*sp.*) on the dorsal side of the meropodite.

Ischiopodite.—The ischiopodite, instead of being broad and flat, as in normal cases, is broadly triangular in cross section, while the line of articulation between it and the meropodite is much less oblique than normal. The motion at this place is normally (in the legs following the cheliped) on an essentially dorso-ventral axis (*d.a.–v.a.*), though due to torsion in the chelipeds it becomes greatly inclined. In the abnormal specimen the dorsal articulation (*d.a.*) appears practically normal, but on the ventral side there are two points of articulation (*v.a.* and *a′.*). Being thus hinged at three places the joint is stiff and incapable of movement in any plane. The row of spines running down the ventral side of the meropodite and continued on the ischiopodite, proves the articulation (*v.a.*) in line with these to represent the normal one, while the other (*a′*) is secondary.

The articulation between the ischiopodite and the basal podomeres is apparently normal, though the ischiopodite here has on its posterior side a ridge (*r*) which is not present in normal specimens. This ridge ends in a short, blunt process, much like an articular process, but there is no articulation with it. It does in all probability, however, represent such a secondary process, being placed, as in the other joints, midway between the normal points of articulation.

Relations of Symmetry.

Torsion.—It is a matter of common knowledge that in development the cheliped of the lobster undergoes a twisting or torsion, as a result of which the chelæ come to lie in a nearly horizontal plane, that is, almost at right angles to their normal

morphological plane. This is illustrated in Fig. 5. This figure represents diagrammatically a cross section through the index and dactyl of a normal claw from the left side of a lobster, viewed from the position of the distal end of the appendage. The posterior side of the claw, which is more darkly pigmented in the living lobster, is here shaded, while the ventral side is left clear. The primary morphological relations, as they would obtain if the appendage were extended laterally in a horizontal

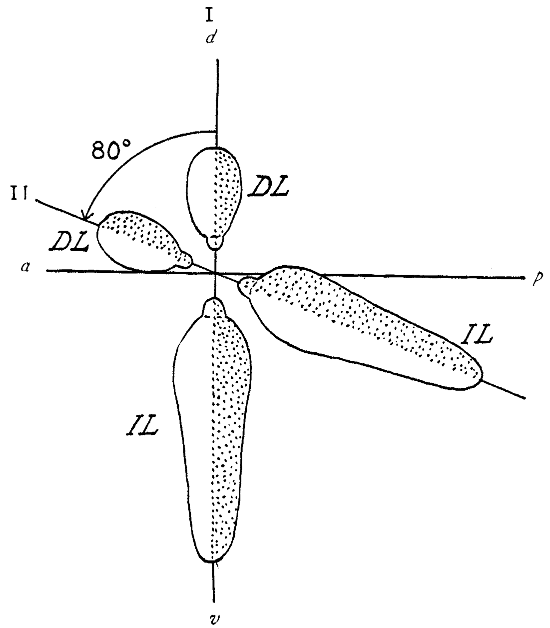

FIG. 5. Diagram to illustrate effects of torsion in a normal left chela. I., primary morphological position; II., position as a result of torsion.

plane and there were no torsion, are shown in the position marked I, where the plane passing through the index (*IL*) and dactyl (*DL*) is vertical. Due to torsion, however, the claw is rotated anteriorly[1] nearly 90° (probably ordinarily 75°–80°; for convenience, we may call it 80°), so that its plane approximates the horizontal, as shown in position II. The dactyl thus lies anteriorly, while the posterior surface (shaded) is uppermost. By a bending of the leg now, however, the claws may be brought

[1] By "rotated anteriorly" it is meant that the *dorsal* side has rotated over in the *anterior* direction.

around into the position in which they are normally carried, that is, ahead of the lobster and pointing forward or even inward. As a result the dactyl comes to lie on the side toward the median plane, or even directed posteriorly. The primary claw in Figs. 1 and 2 has nearly the normal position, but as will be pointed out below, the torsion and bending are less than is usual. Emmel (**1907**, p. 140) has emphasized the importance of taking into account the normal torsion in considering the relations of supernumerary parts in abnormal chelipeds.

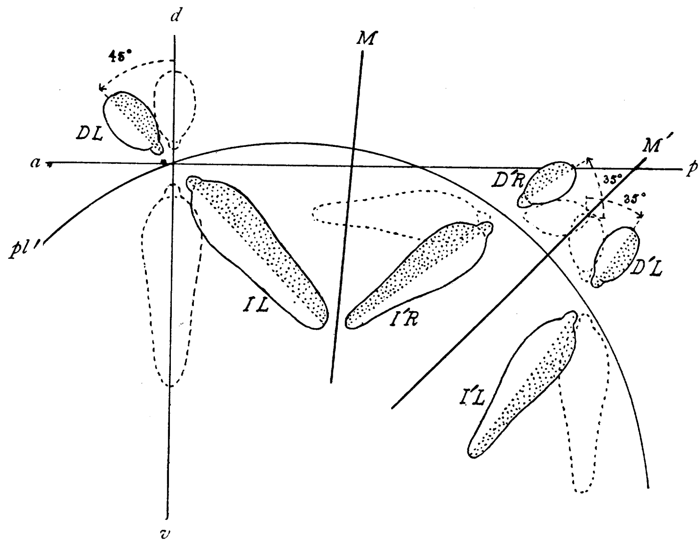

FIG. 6. Diagram showing the spacial relations and secondary symmetry in the abnormal cheliped (full outlines). The dotted outlines show the theoretical relations these parts should have in accordance with the "rules of secondary symmetry," leaving torsion out of account.

In Fig. 6, by a similar diagram, are represented the conditions, as regards rotation, of the three claws of the abnormal specimen. As before, the appendage is considered as being extended straight out laterally from the body. It will be noted that as a result of the abnormal outgrowth the primary claw (*IL*, *DL*) has rotated only about 45° from the vertical plane instead of nearly 90° as in the normal (Fig. 5). The amount of torsion in the abnormal chelæ will be discussed below with the consideration of the relations of right and left. It may be said here, that as

in the case of the claw, the torsion of the more proximal parts of the limb appears also to have been hindered by the abnormality.

Secondary Symmetry: Dextro-sinestral Relations.—Like most abnormal crustacean appendages with extra processes, the present case falls into the category "in which the extra limb or extra parts of a limb are themselves morphologically double." Furthermore, in accordance with the rules of secondary symmetry laid down by Bateson (**1894**, p. 479), the normal appendage and the extra parts lie in the same plane[1] and "the nearer of the two extra appendages is in structure and position formed as the image of the normal appendage in a plane mirror [*M*, Fig. 6] placed between the normal appendage and the nearer one, at right angles to the plane of the three axes; and the remoter appendage is the image of the nearer in a plane mirror [*M'*, Fig. 6] similarly placed between the two extra appendages." Thus the two extra claws are morphologically a pair and belong to opposite sides of the body, the inner or proximal one, according to the above rule, being a morphological right (the primary claw being a left), and the outer one a left. This is evident in the diagram (Fig. 6), where it will be noticed by the shading that the relations of the posterior (shaded) and anterior (not shaded) halves are reversed in the middle claw. In one respect, however, the middle claw is not a right; for the normal right claw of this lobster was in all probability of the "nipper" type, the left being a "crusher." As a matter of fact the teeth on both the indices and dactyls of all three of the claws of the abnormal appendage (*IL, DL; I'R, D'R; I'L, D'L*) are of the "crusher" type. Thus it is evident that while the rules of secondary symmetry hold good for the *spatial relations* they do not apply to the *character* of the parts of the appendage when these normally differ on the two sides of the animal.[2]

Bateson (**1894**, p. 479, *et seq.*) has shown that a definite relation obtains between the position which the extra parts assume to each other and to the primary appendage, according to the side of the appendage from which they arise. The theoretical positions he has illustrated plainly by means of a diagram (*loc.*

[1] This plane (Fig. 6, *pl'*.) is bent in the present case, owing to torsion. See later.

[2] Emmel (**1907**, p. 110) found the same thing to be true in his "specimen No. 5."

cit., Fig. 154) of the leg of an insect, and most of the cases fit in with these expectations very well.

Adapting to the lobster Bateson's diagram for the theoretical positions of the extra parts when they arise from the ventro-posterior (*v.p.*) side of the normal appendage, as in the present case, we have the relations as shown by the complete outlines

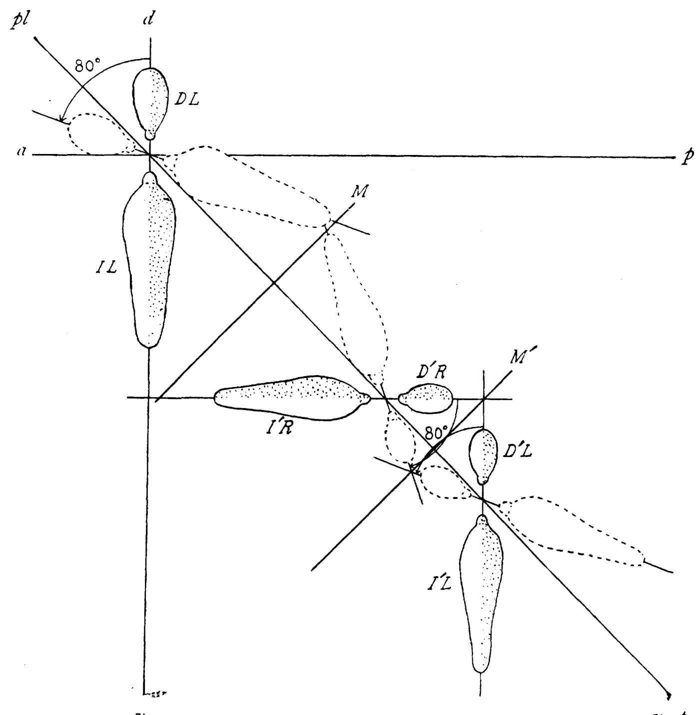

FIG. 7. Diagram illustrating (full outlines) Bateson's "rules of secondary symmetry" as applied to a left lobster chela with double extra claws arising from the ventro-posterior side. The dotted outlines show the positions these parts would assume if each claw were rotated anteriorly, independent of the others, through an arc of 80°.

in Fig. 7, no allowance being made for torsion. But we have seen (*p.* 259) that the normal lobster claw becomes rotated anteriorly through an arc of approximately 80°. If we now rotate independently toward its anterior side each of the diagrammatic claws in Fig. 7 through an arc of 80°, we arrive at the posi-

tions indicated by the dotted outlines in the same figure. Referring now to Fig. 6, which represents (by the unbroken outlines) the actual positions of the claws, we find that whereas the primary claw has rotated in the expected direction—though only about 45° instead of 80°—the secondary claws appear each to have rotated towards their morphological *dorsal* sides about 35° from the planes prescribed in the theoretical diagram (Fig. 7, full outlines). These relations are perhaps to be accounted for as follows:

While there is some torsion in the base of a normal cheliped, this is compensated for by the rotation of the appendage forward, as a result of which the axis of articulation at the base of the propodite, which is morphologically dorso-ventral, is essentially vertical, as it is in the succeeding pereiopods. Hence the position of the great claw is for the most part due to a *torsion in the propodite itself*. In our abnormal specimen, the axis of articulation of the propodite to the carpopodite lies also, as we have seen, practically in a vertical plane; but, apparently as a result of the mechanical hindrance of the secondary growth from its base, the primary propodite has been able to turn only 45° instead of 80° from that plane.

The positions assumed by the secondary claws are a little more difficult of explanation. Since, however, they have a tendency to rotate in opposite directions, the plane (M') midway between them should remain constant in position whatever the amount of torsion, as shown in Figs. 6 and 7, and we may first consider the relation of this plane to that of the primary claw. By reference to Fig. 7 we see that this plane, in the case of a double extra process arising from the postero-ventral surface of an appendage, should make an angle of 45° with the dorso-ventral plane (*d.-v.*). A glance at Fig. 6 will now show that the plane M' there makes the same angle (45°) with the primary dorso-ventral plane of the abnormal specimen. As a result, however, of the torsion distad of the point of divergence, the three claws no longer lie in the same plane (*pl.*, Fig. 7) which passes through the point of origin of the extra parts, but a line connecting their centers has to curve as shown by *pl'*. in Fig. 6.

We have already noted that the planes of the secondary

claws lack 35° of being turned as far as called for by the theoretical positions (solid outlines, Fig. 7), to say nothing of the additional 80° which would be necessary for them to assume the positions as a result of normal torsion (dotted outlines, Fig. 7). As a matter of fact, this torsion should *not* be expected in the secondary claws, since they divide from each other at a considerable distance from the base, and the torsion of the propodite takes place entirely, or practically so, at its base. There would be no torsion in the basal part of the extra outgrowth, since in that region which is potentially double, the tendencies to rotation in opposite directions would neutralize each other. The divergence of the primary claw being further proximal, that has been able to undergo some rotation (45°) as already described. Now as to the failure of the planes of the secondary claws to lie at right angles to each other, as they should, according to Fig. 7, if torsion is eliminated. This is probably to be accounted for upon mechanical grounds, the union of the parts only a short distance proximad interfering with and restricting the divergence of these planes. If the double outgrowth had taken its origin upon a more basal portion of the appendage, it is safe to assume that the planes of the distal claws would have attained more nearly the theoretical positions.[1]

The relations of secondary symmetry in the more proximal parts of the appendage appear to be amenable to the same rules; but owing to the way in which the various parts are "compounded" (to use Bateson's term) before they actually divide, this exposition becomes extremely complicated and would serve no useful purpose at this time, since the discussion given above as to the relations of the claws has served to illustrate the factors involved. This compounding accounts for the absence of large spines along the dorsal side of the extra propodite, which has already been mentioned.

[1] In Emmel's interesting "specimen No. 5" the extra chelæ arose from the meropodite, and he here found (the union being further proximad) that each of the claws had undergone a full rotation, each in its normal direction of torsion. According to his description (Emmel, **1907**, p. 141) the primary or normal claw had rotated 90°, but *each of the extra claws had rotated* 180°! Why this should have been seems difficult to understand and Emmel offers no explanation. Why, with the direction of torsion opposed in contiguous claws, its amount should be limited to less than 90°, as in the specimen here described, is obvious; but why in any case it should be *greater* than 90° seems inexplicable.

Cause of the Abnormality.

While believing that we must ultimately look to experiment for the elucidation of the causes of abnormalities of this sort, there are nevertheless certain considerations in the present instance which are of interest. On the theory that they may be the result of injuries, marks indicating such injury have often been sought. The scar of an evident injury is very noticeable on the carpopodite of the present specimen (Fig. 3, *s.*); but is is equally evident that this injury cannot have been the the cause of the abnormality, since, as we have seen, the effect of the doubling is obvious as far proximad as the ischiopodite. It seems more probable that after some antecedent autotomy of the appendage the regenerating bud was in some way injured or disturbed so as to produce the abnormality. A definite scar for such an injury could not be expected in the fully developed appendage. Not only would it be of the greatest importance to know whether this abnormality would be reproduced if the leg could have been amputated autotomously and allowed to regenerate (cf. Emmel, **1907**, p. 111), but it would also be interesting to know whether a lobster could moult normally with an appendage of this sort. On account of the extra amount of material involved, which would have to be drawn through the narrow opening at the base of the leg, it would certainly be a much more precarious ordeal than usual.

Summary.

In this paper is described the abnormal cheliped of a lobster (*Homarus americanus*), the abnormality consisting of a double extra claw. While the extra part actually separates from the normal propodus, it is shown that the effects of the doubling may be traced to the base of the leg. It is further shown that the conditions in this appendage illustrate almost diagrammatically the "rules of secondary symmetry" formulated by Bateson, if allowance be made for the effects of the torsion which occurs in the normal lobster cheliped and the mechanical conditions which may modify such torsion.

Addendum.

Since it is of advantage to place on record where they may be found the cases of abnormal crustacean appendages, it may be well to call attention here to two recent records which might naturally be overlooked. They both occur on crabs, and both belong to the class of "extra processes arising from the normal dactyl," being directly comparable to the chelæ figured by Emmel (**1907**, pl. 1, Fig. 1), Faxon (**1881**, pl. 1, Figs. 1, 2, 3, 4, 5, 7, 8), Herrick (**1895**, pl. 47, Fig. 191), and Bateson (**1894**, Figs. 184, 185).

The first case is fiured incidentally by Verrill (**1908**, p. 396, Fig. 37) in his report on the "Decapod Crustacea of Bermuda."

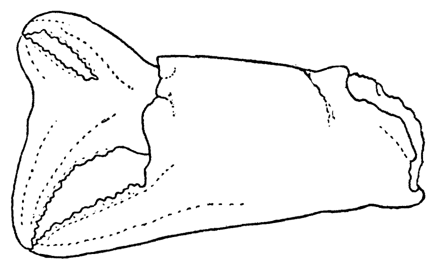

Fig. 8. Deformed claw of an undetermined cancroid crab. (After Verrill.)

Fig. 8 represents the condition of this specimen, which is described as the "deformed claw of an undeterminal cancroid crab."

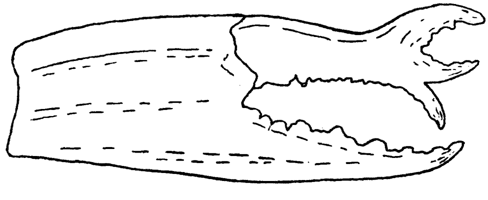

Fig. 9. Abnormal crab claw from Stonington, Conn. (After Leavitt.)

The second case (Leavitt, **1909**), illustrated in Fig. 9, is of a crab, possibly *Callinectes*, from Stonington, Conn. The author states that there was a brief mention of this claw in *St. Nicholas* for December, 1907. He makes the mistake of considering this a reduplication of the entire claw, except that "in the small pincer the dactyl is not movable at the base, as it is in the larger

one." Further, he calls it a case of "homœosis" and gives a general consideration of it in relation to Weismannism, etc.

LITERATURE.

Bateson, W.

'94 Materials for the study of variation, treated with especial regard to discontinuity in the origin of species. London, xvi + 598 pp.

Emmel, V. E.

'07 Regenerated and abnormal appendages in the lobster. 37th Ann. Rept. Commissioner of Inland Fisheries, Rhode Island, pp. 99–152, pl. 1–9.

Faxon, W.

'81 On some crustacean deformities. Bull. Mus. Comp. Zool., vol. 8, no. 13, pp. 257–274, pls. 1, 2.

Herrick, F. H.

'95 The American lobster: A study of its habits and development. Bull. U. S. Fish Comm., 1895, pp. 1–252, pl. A–J, 1–54.

Leavitt, R. G.

'09 An interesting crab's claw. The Guide to Nature, vol. 3, no. 3, pp. 89–91.

Verrill, A. E.

'08 Decapod Crustacea of Bermuda, I. — Brachyura and Anomura. Trans. Conn. Acad. Arts and Sci., vol. 13, pp. 299–474, pl. 9–28.

Explanation of Abbreviations Used in Figures.

a., anterior.

a'., secondary point of articulation of ischiopodite to meropodite.

a.p., anterior articular process of meropodite.

C., carpopodite.

$C+[C'(R+L)]$., carpopodite of abnormal specimen, compounded of the primary and secondary parts.

d., dorsal.

d.a., primary (normal) dorsal articulation of ischiopodite to moropodite.

DL, left primary or normal dactyl.

D'L, left extra dactyl.

d.p., primary (normal) dorsal articular process of carpopodite.

d.p'., extra (secondary) dorsal articular process of carpopodite.

D'R., right extra dactyl.

I, index.

IL, left primary or normal index.

I'L, left extra index.

I'R, right extra index.

Is, ischiopodite.

M, line representing position of a plane mirror placed midway between the primary claw and the nearer secondary claw, and normal to the plane in which they lie.

M', line representing position of a plane mirror placed midway between the extra claws and normal to the plane in which they lie.

Mer., meropodite.

p., posterior.

p'., process representing an incipient secondary articular axis between meropodite and carpopodite.

pl., plane passing through the point of origin of the secondary growth from the primary claw and through both the extra claws.

pl'., curved line representing the bending of the plane *pl.* as a result of torsion and the mechanical conditions.

pp., primary (normal) posterior articular process of meropodite.

Pr., propodite.

Pr L, left primary or normal propodite.

Pr' $(R+L)$, extra double propodite.

r., ridge at base of ischiopodite, possibly representing a secondary incipient point for articulation with basal podomeres.

s., scar on base of abnormal carpopodite.

sp., large spine on meropodite.

SpD L, spine at base of primary or normal dactyl.

SpD' L, spine belonging to base of left extra dactyl.

SpD'R, spine belonging to base of right extra dactyl.

v., ventral.

v.a., primary (normal) ventral articulation of ischiopodite to meropodite.

v.p., primary (normal) ventral articular process of carpopodite.

v.p'., extra (secondary) ventral articular process of carpopodite.

v.–p., ventro-posterior, the side of the primary claw from which the extra claws arise.

x., smooth spot where the secondary dorsal articular process (*d.p'*.) of the carpopodite has rubbed against the base of the propodite.

I., position before torsion.

II., position as a result of torsion.